

DETECTION OF STELLATES AND MASSES IN DIGITISED MAMMOGRAMS

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Abstract- If detected early, breast cancer can be treated with better patient outcomes and significantly lower costs. From recent (1998) retrospective breast cancer studies, in approximately half of missed cases, a minimal sign was already visible on a prior mammogram. Using information technology such as spatial dendrograms (stealth-related technology) and repartment hierarchical identification (successive information peeling), difficult cases of spiculated and stellate tumours can be identified. The techniques are robust to noise and can reveal various layers of biophysical and biomedical differences in a tumour.

Keywords - Mammogram, stellates, dendrogram, repartment.

I. INTRODUCTION

Breast cancer can be controlled and treated successfully when detected at early stages. From recent retrospective breast cancer studies [1-2], in approximately half the missed cases and 28% of interval cancers, a minimal sign was already visible on a prior mammogram. Because survival rates are highest (early diagnosis can triple the 10-year survival rate) and recurrence and treatment costs are lowest if the cancer is detected and treated at an early stage (the cost of late stage cancer treatment is 10 times higher than for early stage cancer), it is critical to diagnose breast cancer in its earliest stage.

The mammographic appearance of normal breast tissue varies widely and the signs of breast cancer are very subtle. The evaluation of screening mammograms is a very difficult task where the radiologist must balance the requirement of high sensitivity for abnormalities (leading to high cancer detection) and high specificity for normality (keeping unnecessary biopsies to a minimum). Approximately half of the undetected cancers are missed due to observational oversights. Many screening errors are perception errors and it may be necessary to draw the attention of the radiologist to a tumour which might have been overlooked or to an abnormal area on a mammogram that needs careful attention [1].

Despite a large research literature on image processing in mammography, the detection of cancerous mass lesions is still very difficult for many reasons. Masses are often of varying size, shape, and density, at the same time exhibiting poor image contrast. In addition, many mass lesions and normal parenchymal tissues surrounding them look similar on mammogram [3-4]. For these reasons, screening mammograms are usually read independently by two radiologists to reduce false negatives and interpretation errors [5].

II. METHODOLOGY

A. Dendrograms

In order to reduce the number of missed cases, a number of advanced detection strategies are proposed. In general, malignant mammographic densities have an irregular appearance, often surrounded by a radiating pattern of linear spicules. Sometimes the density is very faint, and when it is embedded in the parenchymal tissue, it may be very hard to perceive [6]. For this problem, a stealth-related extraction technology for “low observables” is being researched by us to extract subtle signs of breast cancer. A dendrone is a hierarchical thresholding structure which can be automatically generated from a complex image [7-8]. The dendrone structure captures the connectedness of objects and sub-objects during successive brightness thresholding. Based upon connectedness and changes in intensity contours, dendronic representations of objects in images capture the coarse-to-fine unfolding of finer and finer detail, creating a unique signature for target objects which is invariant to lighting, scale, and placement of object within the image. Sub-dendrones within the hierarchy are recognisable as objects within the picture. Complex composite images can be autonomously analysed to determine if they contain the unique dendronic signatures of particular target objects of interest.

The construction of dendrones involves segmenting the image into isolated objects and building the tree structure from these objects. While the structure of the dendrone is generally sufficient to match objects with similar brightness topology, matching objects with similar shape is more difficult. The construction of dendrones is accomplished by thresholding the image in a repetitive fashion. At one particular thresholding intensity level, the image is processed in two stages: image segmentation and object merging. The pixel labelling (or connected components) algorithm presented in [9] is used for segmenting a thresholded image into isolated objects. Essentially, the construction of dendrones can be visualised as decreasing water level on an imaginary 3D intensity terrain. This approach works particularly well for an image with a dark background and bright foreground as in mammograms. Decreasing the water level from full to empty can reveal the relationships among the objects in the image, and allow faint objects such as stellates to show up clearly.

Dendronic image analysis is a completely neutral, data-driven, self-structuring process. The dendrone is robust to noise, free of contextual information, and invariant under Euclidean

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geometric transformations. Dendronic signatures have significant potential to provide the basis for an operational capability to detect probable target object identities between multiple images and to recognise and verify similar features in a wide variety of image contexts.

The dendrone's ability is largely dependent upon the 'stride' value (the incremental thresholding reduction at which the image is segmented). If the stride corresponds closely to the optimum thresholding value (i.e. breakup of light intensity in the image) then the dendrone can work well but a preprocessing is desirable for achieving the starting region in mammograms within an acceptable time in clinical application. Given suitable parameters a spatial dendrogram (dendrone) can be used to usefully process a suspect region of interest in a mammogram.

B. Hierarchical Repartment

For the extraction of breast masses, a novel technique using repartment hierarchical identification will be used. Based on the profile compactness, a dimensionless parameter which characterises the shape of an object as shown in Figure 1, we propose to use a repartment hierarchical technique to provide successive peeling processes until the required object such as a stellate can be found. This should be of particular value in cases with architectural distortion.

The *repartment*, derived from the information theory, is given by:

$$H(Q_1, Q_2, \dots, Q_n) = -\lambda \left(\frac{Q_1}{Q} \ln \frac{Q_1}{Q} + \frac{Q_2}{Q} \ln \frac{Q_2}{Q} + \dots + \frac{Q_n}{Q} \ln \frac{Q_n}{Q} \right)$$

where Q_1 is the boundary compactness using the 1st peeling process, and Q_n is the boundary compactness using the n^{th} peeling, λ is a positive constant, and $Q = Q_1 + Q_2 + \dots + Q_n$ [10].

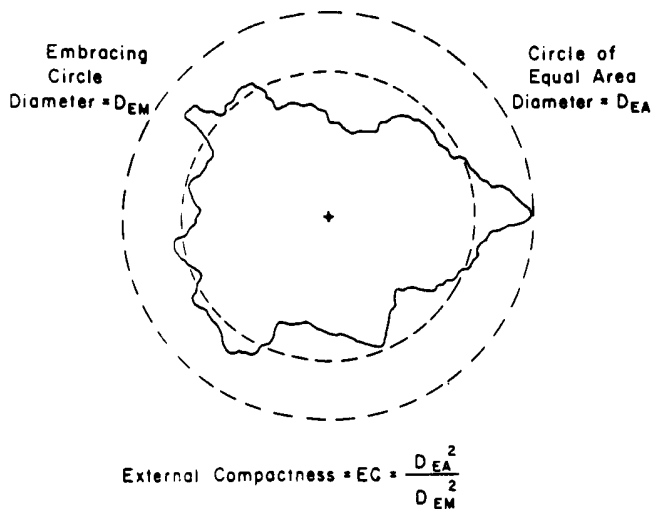


Fig. 1. The compactness of a profile from a series of successive peeling

The repartment hierarchical technique has been developed for peeling successive layers of contrast boundaries from a suspect region of interest. These layers may include background (the non-breast region), pectoral muscle, fibroglandular region (parenchyma), adipose tissue, etc. [11]. Compactness is a parameter sometimes used for the single visible border of a mass for identification but is limited to that border whereas our approach enables successive values to be obtained by the "peeling" process in order to generate the new parameter of hierarchical repartment for mammograms. This will be of importance for identifying difficult cases of spiculated and stellate tumours, particularly with architectural distortions.

This new method may be able to identify a suspect object as a tumour (with structure) or just a non-tumour object. This is an important process. For example, it can reveal the important layers of biophysical and biochemical differences in a tumour from which parameters can be obtained for prognosis, growth rate, etc. and for possible ex-surgical recurrence references [12].

III. RESULTS

Additional use of signature codes in difficult cases and in training of radiologists is a promising application of the development. The dendrogram in this particular application is used for generating a signature structure code in order to search a database of pathologically proven cases.

Figure 2 and Figure 3 show the mammographic images and corresponding dendrograms of a benign stellate and a malignant stellate respectively. Our investigations of dendrograms of mammographic images have indicated that the "bar-code" signatures of suspect masses are diagnostic.



Fig. 2. Mammographic image of a benign tumour and its dendrograms



Fig. 3. Mammographic image of a malignant tumour and its dendrograms

Essentially, the new hierarchical repartment parameter is based on the successively revealed intensity levels phenomena of a suspect region and surrounding tissue for application in diagnosis and recurrent probability. There is micro-biological and biophysics reason for this because of a loss of heterozygosity in the surrounding tissue and a proven change in dielectric constant both with the cells and collectively for the tissue involved.

Two mammographic images and the corresponding results using the repartment hierarchical technique are shown in Figure 4 and Figure 5 respectively.

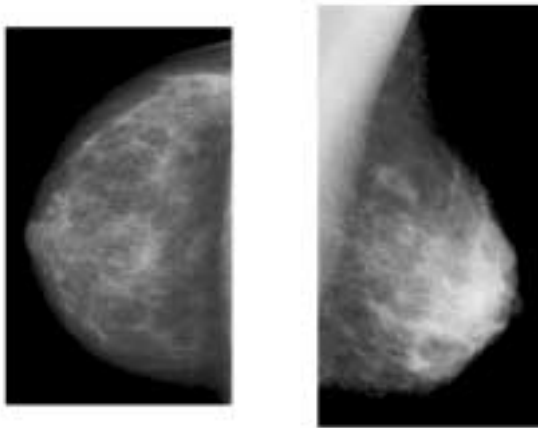


Fig. 4. Two mammographic images

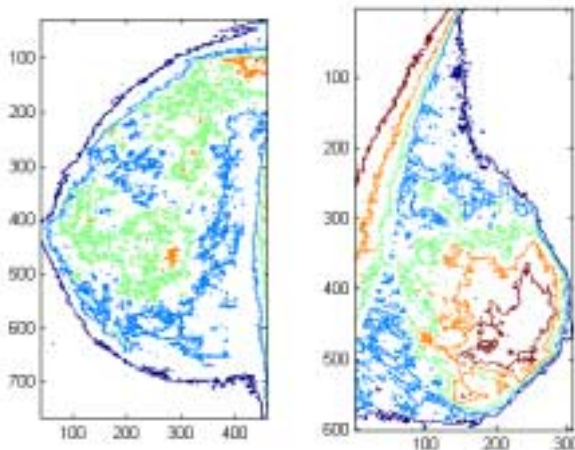


Fig. 5. Corresponding repartment hierarchical peeling images

IV.CONCLUSION

The combined sequential method proposed is aimed at providing a new approach to aid radiologists by indicating a suspect region of interest which might otherwise be missed in the breast screening process. The advantage promised by each individual method is captured in a manner which should enable the important time requirement to be reduced from that taken by the methods if used separately.

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